Using LS-DYNA Implicit for Metal Forming Applications

Cleve Ashcraft

Roger Grimes

Xinhai Zhu

LSTC

Livermore Software Technology Corporation

Implicit for Metal Forming Applications

- Want to use Implicit for phases of metal forming applications such as
  - Springback
  - Gravity loading

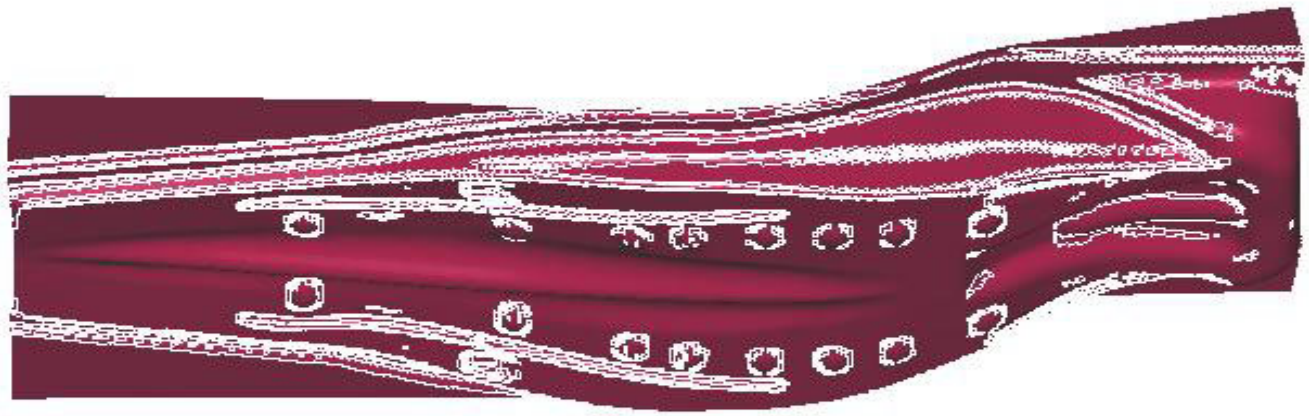
Springback

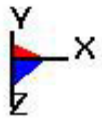
- LS-DYNA has long supported springback computations
  - Seamless switching from explicit to implicit in the same execution
  - Options to assist convergence
  - Now we can reduce the wall clock time using MPP

Springback Example

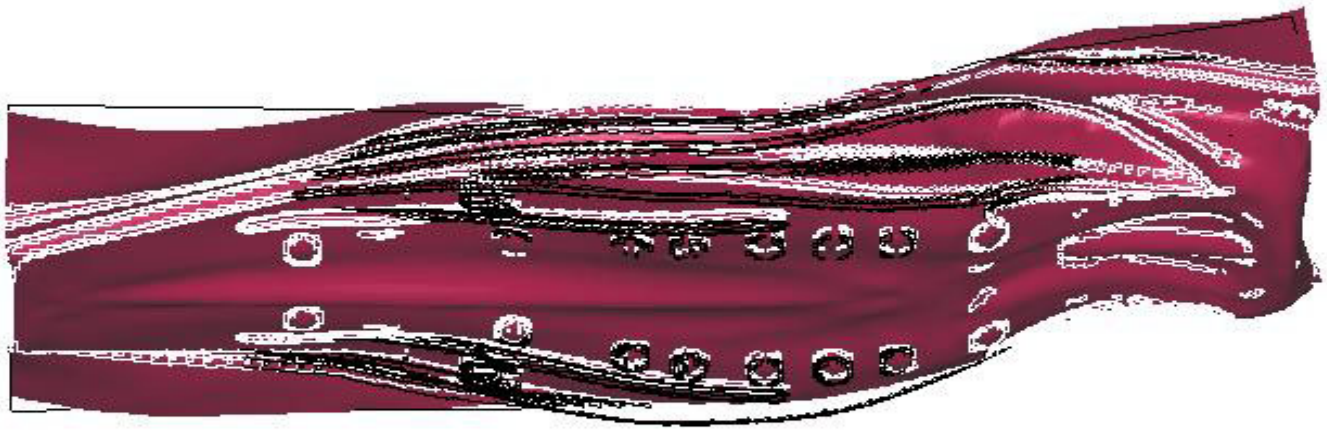
- Springback Model
  - Floor pan
  - 188K shell elements, 204K nodes
  - 1 transient time step, 47 Full Newton Iterations
  - 1.04M rows and 28.3M nonzeroes in **K**

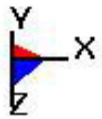
Time = 0





Time = 0.1
max displacement factor=10





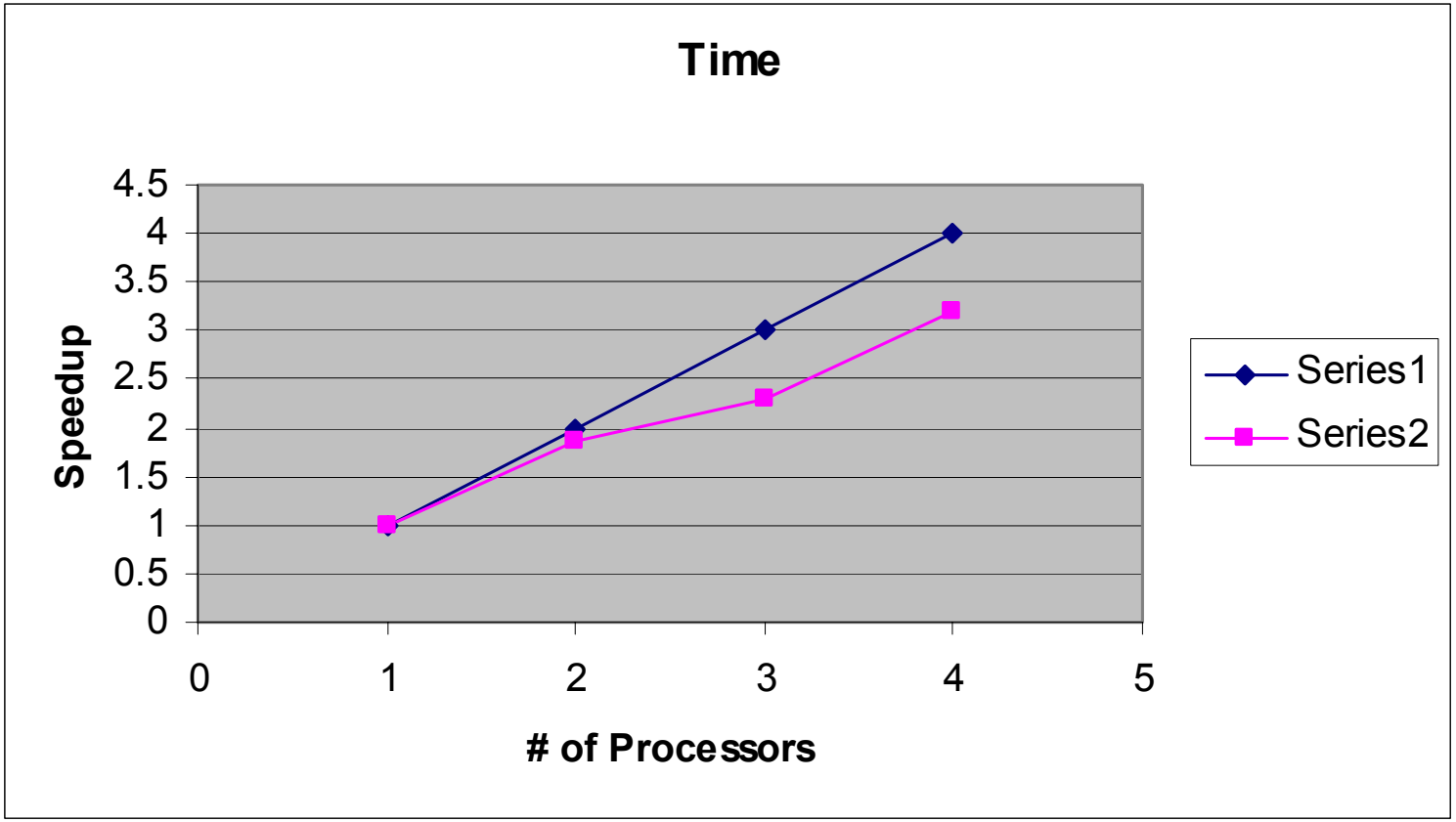
Implicit Performance

	Wall Clock (minutes)	Memory
Serial	131	678 Mw
MPP-1 proc	154	682 Mw
MPP-2 proc	88	366 Mw
MPP-3 proc	73	231 Mw
MPP-4 proc	55	210 Mw

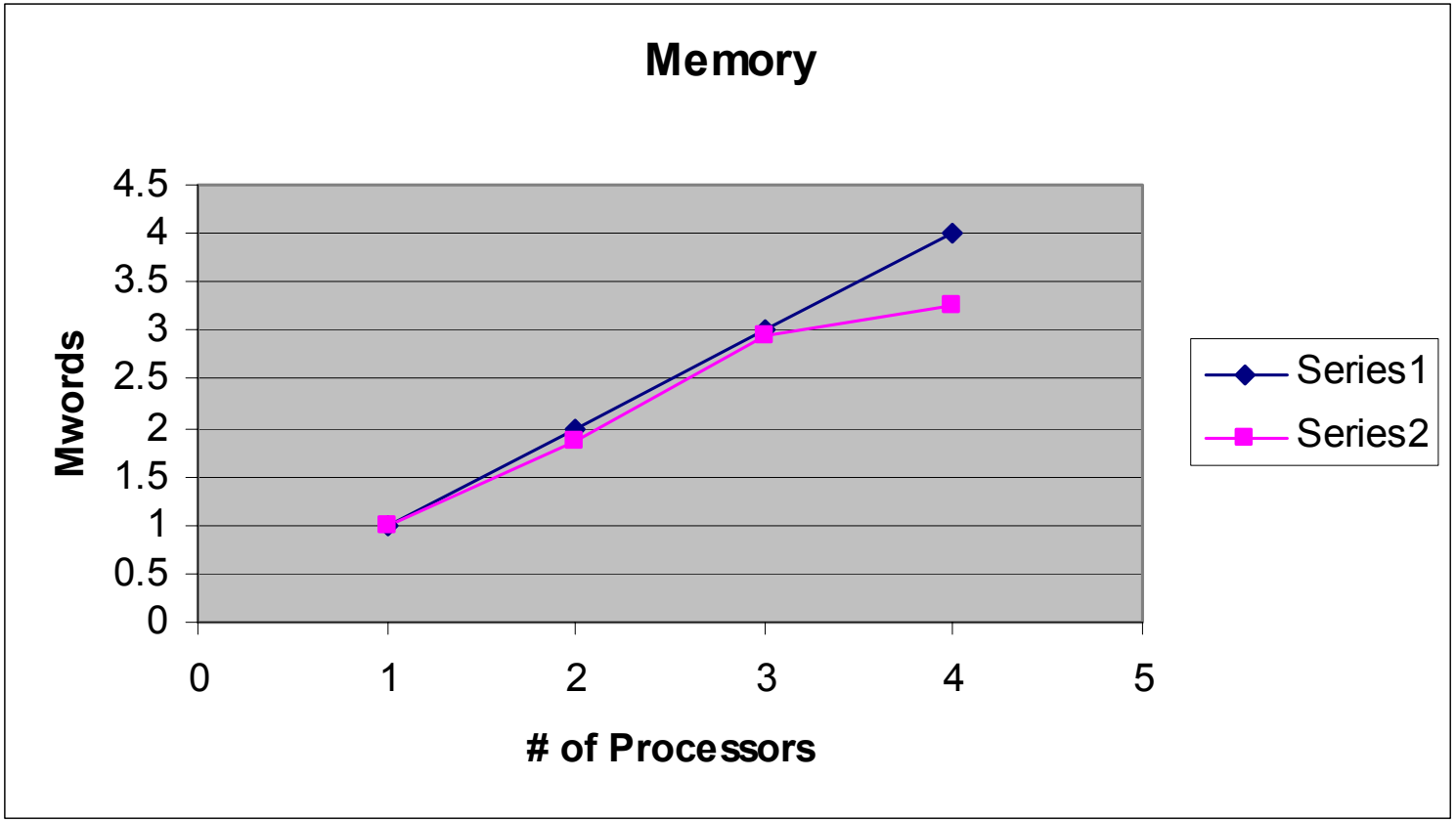
Ratios

	Time Max.	Time Speedup	Memory Max.	MemoryRatio
1	144	1.00	682	1.00
2	78	1.85	366	1.86
3	63	2.29	231	2.95
4	45	3.20	210	3.25

Plot of Time Speedup



Plot of Ratio of Max. Memory



Implicit Performance Issues

- Currently working on factor work distribution that caused 3 processor wall clock time to be higher than expected.
- Examining memory use regarding scalability
- Implementing small number of processor run time switch to overcome parallel overhead for 1 and 2 cpu jobs.

Gravity Loading

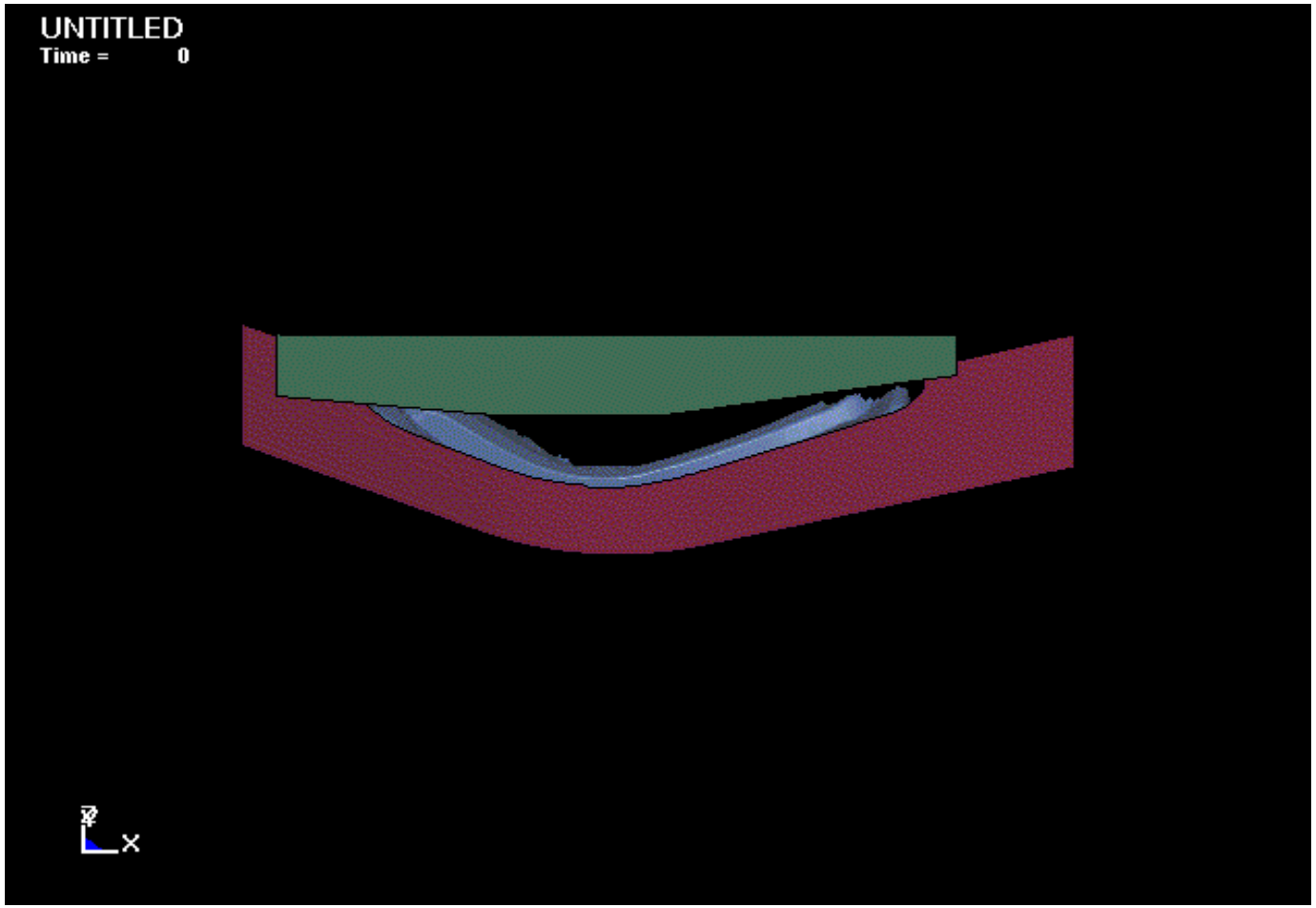
- Since the workpiece is free to move implicit statics has a singular stiffness matrix.
  - Typical solution is to use implicit dynamics but this does not yield the desired static solution
- We have added 2 new features to overcome this problem
  - Death and burial times for implicit dynamics
  - Automatic tie constraint generation

Death and Burial Times for Implicit Dynamics

- The idea is to gradually ramp down the effects of dynamics over several time steps starting at the death time until zero at the burial time.
  - Allows use of dynamics to overcome initial singularities and then converge to static solution.
  - Still not sufficient for gravity loading.

Automatic Tie Constraints

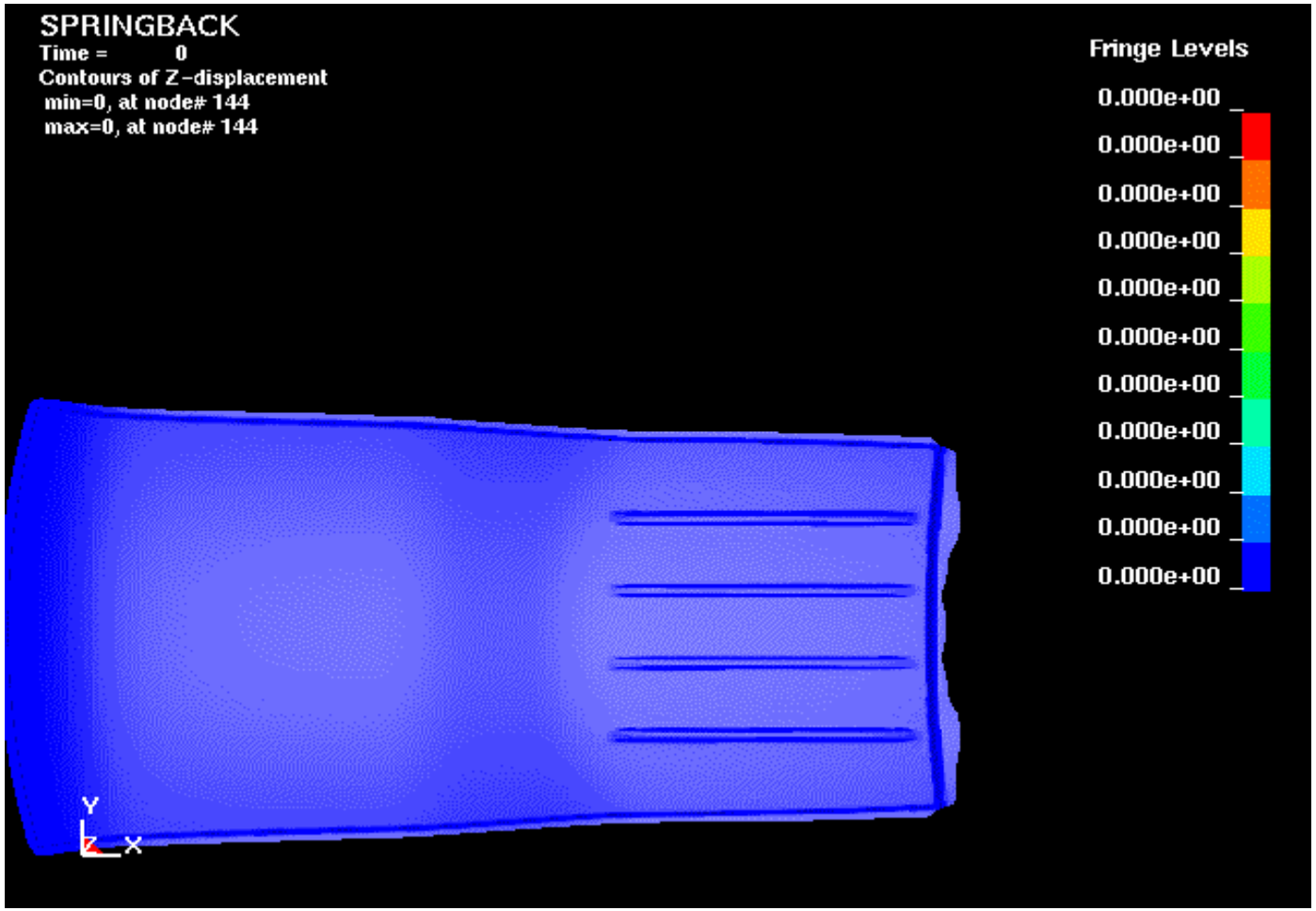
- To remove singularities for gravity loading we must tie the work piece down to suppress rigid body motions.
- We have an experimental approach to automatically generate such tie constraints.
- Seems to work well for gravity loading of metal forming applications.

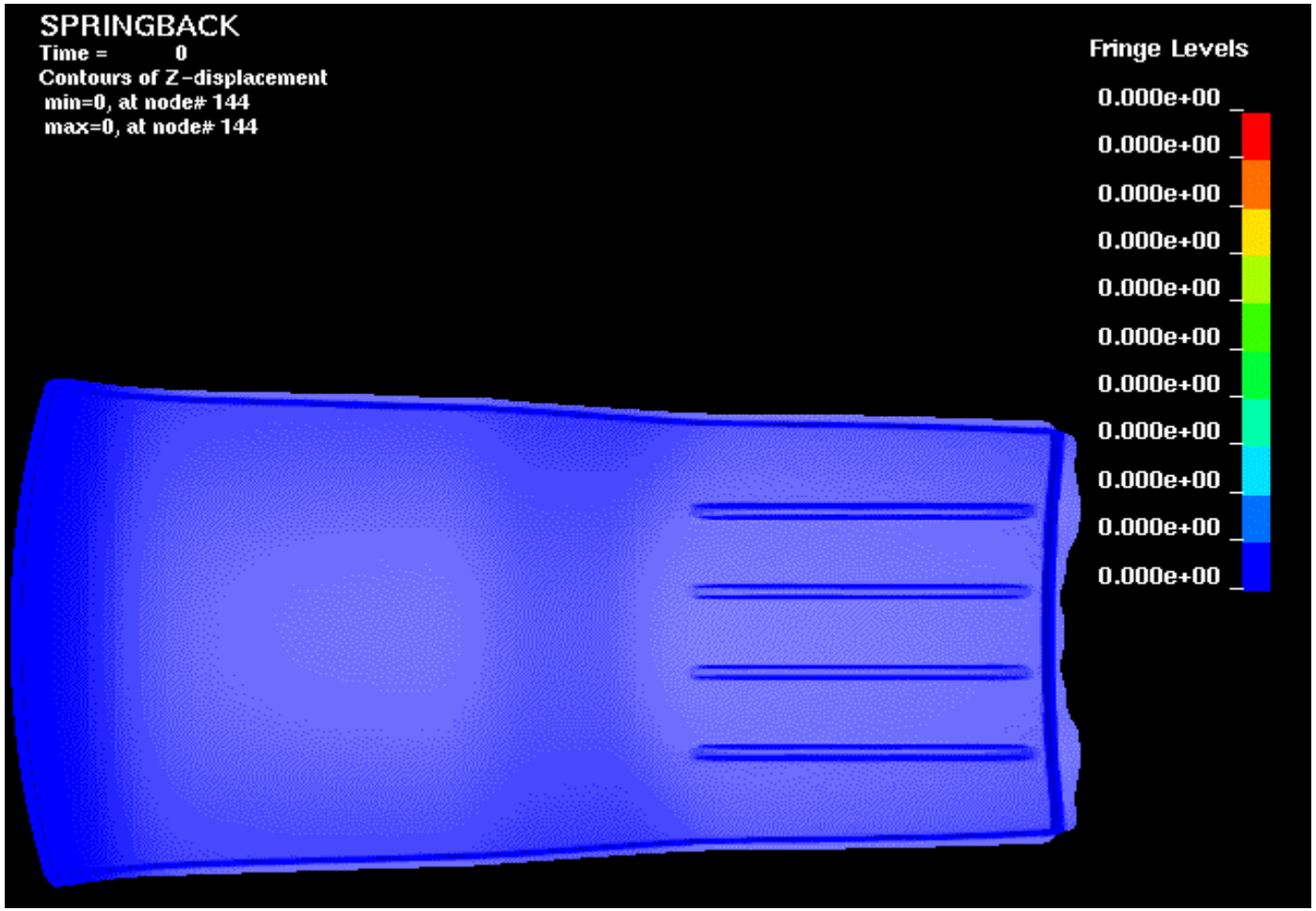

UNTITLED
Time = 0
Y
X

Gravity Loading
and
Springback with Support

- Model is from Ford
- Coarse model has
  - 99681 nodes
  - 87629 elements
- Finer Model has
  - 218277 nodes
  - 208973 elements

SPRINGBACK


SPRINGBACK
Time = 0
Contours of Z-displacement
min=0, at node# 144
max=0, at node# 144
Fringe Levels
0.000e+00
0.000e+00
0.000e+00
0.000e+00
0.000e+00
0.000e+00
0.000e+00
0.000e+00
0.000e+00
0.000e+00
Y
Z
X


SPRINGBACK
Time = 0
Contours of Z-displacement
min=0, at node# 144
max=0, at node# 144
Fringe Levels
0.000e+00
0.000e+00
0.000e+00
0.000e+00
0.000e+00
0.000e+00
0.000e+00
0.000e+00
0.000e+00
0.000e+00

Summary

- LSTC now has MPP Implicit
- MPP Implicit will reduce the wall clock time for metal forming application
- We have added additional features for gravity loading applications